

# Development and Characterization of a Novel Additive Manufacturing Technology Capable of Printing Propellants with High Solids Loadings

Completed Technology Project (2017 - 2021)



## Project Introduction

Ever since rockets have been around, there has been a demand to improve propulsion systems by increasing propellant performance in order to reduce production time and costs. It is known that propellant burning rates can be enhanced with geometric manipulation and that Additive Manufacturing (AM), particularly Fuse Deposition Modeling (FDM), has demonstrated its ability to create unique geometries with high resolution at lower costs. However, it is currently impossible to print heterogeneous materials with high solids loadings. This is an issue because many solid and hybrid propellants rely on high solids loadings for high performance. Solids loadings could be lowered, but this would significantly reduce performance. The purpose of this proposal is to present a new AM technology that has been demonstrated to print heterogeneous materials with solids loadings comparable to current industry standards. This is revolutionary because propellants that were previously regarded as unprintable can now be printed, which opens the door to improve propellant burning rates with new geometries. This technology is very new and needs to be developed and understood through parameter characterization. System properties such as nozzle dimensions and printing path and material properties such as viscosity and reaction characteristics will be studied to determine material printability. The mechanical integrity of the prints will be tested as well. Compatible propellants that are competitive with industry standards will be printed into unique geometries and with functionally graded regions where the burning rate varies locally by varying the distribution of reactive additives. The burning rate of those samples will be compared to cylindrical samples in order to determine those effects. Promising geometries will be scaled up to a small rocket motor and will be compared to standardly used grain geometries.

## Anticipated Benefits

The purpose of this proposal is to present a new AM technology that has been demonstrated to print heterogeneous materials with solids loadings comparable to current industry standards. This is revolutionary because propellants that were previously regarded as unprintable can now be printed, which opens the door to improve propellant burning rates with new geometries.



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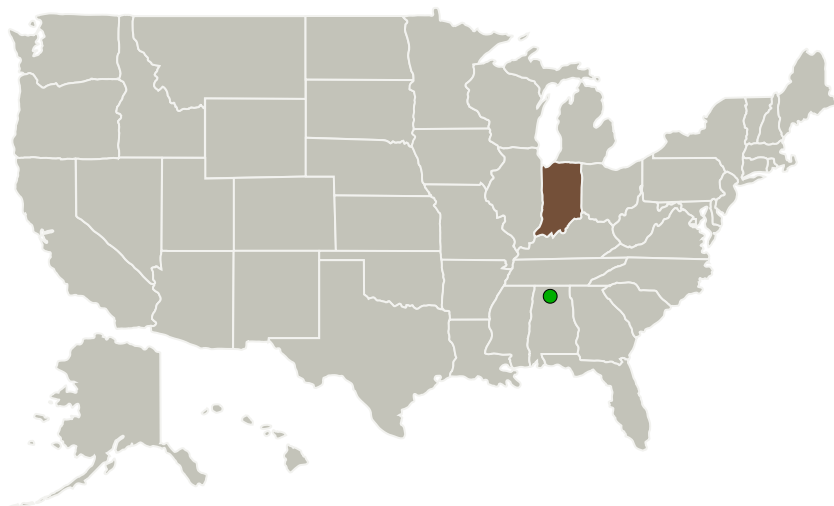
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Purdue University-Main Campus	Lead Organization	Academia	West Lafayette, Indiana
● Marshall Space Flight Center (MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

## Primary U.S. Work Locations

Indiana

## Project Website:

<https://www.nasa.gov/strg#.VQb6T0jJzyE>

## Organizational Responsibility

### Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

### Lead Organization:

Purdue University-Main Campus

### Responsible Program:

Space Technology Research Grants

## Project Management

### Program Director:

Claudia M Meyer

### Program Manager:

Hung D Nguyen

### Principal Investigator:

Steven Son

### Co-Investigator:

Monique McClain

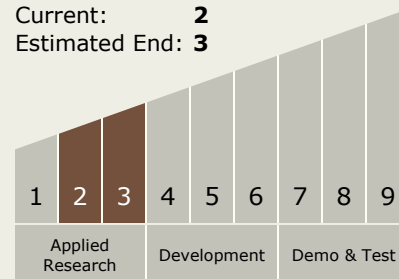
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## Technology Maturity (TRL)

Start: **2**  
Current: **2**  
Estimated End: **3**



## Technology Areas

### Primary:

- TX01 Propulsion Systems
  - └ TX01.1 Chemical Space Propulsion
    - └ TX01.1.4 Solids

## Target Destinations

Earth, The Moon, Mars